

# AppArmor (2.3.1) Quick Start

July 14, 2015

www.suse.com

This document helps you understand the main concepts behind AppArmor®—the content of AppArmor profiles. Learn how to create or modify AppArmor profiles. You can create and manage AppArmor profiles in three different ways. The most convenient interface to AppArmor is provided by means of the AppArmor YaST modules, which can be used either in graphical or ncurses mode. The same functionality is provided by the AppArmor command line tools or by editing the profiles in a text editor.

## AppArmor Modes

### complain/learning

In complain or learning mode, violations of AppArmor profile rules, such as the profiled program accessing files not permitted by the profile, are detected. The violations are permitted, but also logged. This mode is convenient for developing profiles and is used by the AppArmor tools for generating profiles.

### enforce

Loading a profile in enforcement mode enforces the policy defined in the profile as well as reports policy violation attempts to syslogd.

Manually activating complain mode (using the command line) adds a flag to the top of the profile, so that `/bin/foo` becomes `/bin/foo flags=(complain)`.

### enforce

Set an AppArmor profile to enforce mode from complain mode.

Manually activating enforce mode (using the command line) removes mode flags from the top of the profile, so that `/bin/foo flags=(complain)` becomes `/bin/foo`.

### genprof

Generate or update a profile. When running, you must specify a program to profile. If the specified program is not an absolute path, genprof searches the `$PATH` variable. If a profile does not exist, genprof creates one using autodep.

### logprof

Manage AppArmor profiles. logprof is an interactive tool used to review the learning or complain mode output found in the AppArmor syslog entries and to generate new entries in AppArmor profiles.

### unconfined

Output a list of processes with open TCP or UDP ports that do not have AppArmor profiles loaded.

## Starting and Stopping AppArmor

Use the `rcapparmor` command with one of the following parameters:

### start

Load the kernel module, mount securityfs, parse and load profiles. Profiles and confinement are applied to any application started after this command was executed. Processes already running at the time AppArmor is started continue to run unconfined.

### stop

Unmount securityfs, and invalidate profiles.

### reload

Reload profiles.

### status

If AppArmor is enabled, output how many profiles are loaded in complain or enforce mode.

Use the `rcaeventd` command to control event logging with `aa-eventd`. Use the `start` and `stop` options to toggle the status of the `aa-eventd` and check its status using `status`.

## AppArmor Command Line Tools

### autodep

Guess basic AppArmor profile requirements. autodep creates a stub profile for the program or application examined. The resulting profile is called “approximate” because it does not necessarily contain all of the profile entries that the program needs in order to be confined properly.

### complain

Set an AppArmor profile to complain mode.

## Methods of Profiling

### Stand-Alone Profiling

Using genprof. Suitable for profiling small applications.

### Systemic Profiling

Suitable for profiling large numbers of programs all at once and for profiling applications that may run “forever.”

To apply systemic profiling, proceed as follows:

1. Create profiles for the individual programs that make up your application (autodep).
2. Put relevant profiles into learning or complain mode.
3. Exercise your application.
4. Analyze the log (logprof).
5. Repeat Steps 3-4.
6. Edit the profiles.
7. Return to enforce mode.

8. Reload all profiles (rcapparmor restart).

## Learning Mode

When using genprof, logprof, or YaST in learning mode, you get several options for how to proceed:

Allow

Grant access.

Deny

Prevent access.

Glob

Modify the directory path to include all files in the suggested directory.

Glob w/Ext

Modify the original directory path while retaining the filename extension. This allows the program to access all files in the suggested directories that end with the specified extension.

Edit

Enable editing of the highlighted line. The new (edited) line appears at the bottom of the list. This option is called *New* in the logprof and genprof command line tools.

Abort

Abort logprof or YaST, losing all rule changes entered so far and leaving all profiles unmodified.

Finish

Close logprof or YaST, saving all rule changes entered so far and modifying all profiles.

## Example Profile

```
#include<tunables/global>

@{HOME} = /home/* /root/ # variable

/usr/bin/foo {
    #include <abstractions/base>
    network inet tcp,
    capability setgid,

    /bin/mount          ux,
    /dev/{,u}random     r,
    /etc/ld.so.cache    r,
    /etc/foo/*          r,
    /lib/ld-*.so*       mr,
    /lib/lib*.so*       mr,
    /proc/[0-9]**       r,
    /usr/lib/**         mr,
    /tmp/               r,
    /tmp/foo.pid        wr,
    /tmp/foo.*          lrw,
    /@{HOME}/.foo_file  rw,
    /@{HOME}/.foo_lock  kw,

    link /etc/sysconfig/foo -> /etc/foo.conf, ...
    deny /etc/shadow    w,
    owner /home/*/**    rw,
```

```
/usr/bin/foobar      cx,
/bin/**              px -> bin_generic
```

```
# comment on foo's local profile, foobar.
foobar {
    /bin/bash          rmix,
    /bin/cat            rmix,
    /bin/more           rmix,
    /var/log/foobar*   rwl,
    /etc/foobar        r,
}
}
```

## Structure of a Profile

Profiles are simple text files in the `/etc/apparmor.d` directory. They consist of several parts: `#include`, capability entries, rules, and “hats.”

### #include

This is the section of an AppArmor profile that refers to an include file, which mediates access permissions for programs. By using an include, you can give the program access to directory paths or files that are also required by other programs. Using includes can reduce the size of a profile. It is good practice to select includes when suggested.

To assist you in profiling your applications, AppArmor provides three classes of `#includes`: abstractions, program chunks, and tunables.

Abstractions are `#includes` that are grouped by common application tasks. These tasks include access to authentication mechanisms, access to name service routines, common graphics requirements, and system accounting (for example, base, consoles, kerberosclient, perl, user-mail, user-tmp, authentication, bash, nameservice).

Program chunks are access controls for specific programs that a system administrator might want to control based on local site policy. Each chunk is used by a single program.

Tunables are global variable definitions. When used in a profile, these variables expand to a value that can be changed without changing the entire profile. Therefore your profiles become portable to different environments.

### Local Variables

Local variables are defined at the head of a profile. Use local variables to create shortcuts for paths, for example to provide the base for a chrooted path:

```
@{CHROOT_BASE}=/tmp/foo
/sbin/syslog-ng {
    # chrooted applications
    @{CHROOT_BASE}/var/lib/*/dev/log w,
    @{CHROOT_BASE}/var/log/** w,
```

```
...
}
```

## Aliases

Alias rules provide an alternative form of path rewriting to using variables, and are done post variable resolution:

```
alias /home/ -> /mnt/users/
```

## Network Access Control

AppArmor provides network access mediation based on network domain and type:

```
/bin/ping {
network inet dgram,
network inet raw,
...
}
```

The example would allow IPv4 network access of the datagram and raw type for the ping command. For details on the network rule syntax, refer to the Part “Confining Privileges with AppArmor” (↑*Security Guide*).

## Capability Entries (POSIX.1e)

Capabilities statements are simply the word “capability” followed by the name of the POSIX.1e capability as defined in the `capabilities(7)` man page.

## Rules: General Options for Files and Directories

| Option                                | File |
|---------------------------------------|------|
| read                                  | r    |
| write                                 | w    |
| link                                  | l    |
| file locking                          | k    |
| file append (mutually exclusive to w) | a    |

## Rules: Link Pair

The link mode grants permission to create links to arbitrary files, provided the link has a subset of the permissions granted by the target (subset permission test). By specifying origin and destination, the link pair rule provides greater control over how hard links are created. Link pair rules by, default, do not enforce the link subset permission test that the standard rules link permission requires. To force the rule to require the test the subset keyword is used. The following rules are equivalent:

```
/link l,
```

```
link subset /link -> /**,
```

## Rules: Denying rules

AppArmor provides `deny` rules which are standard rules but with the keyword `deny` prepended. They are used to remember known rejects, and quiet them so the reject messages don't fill up the log files. For more information see Part “Confining Privileges with AppArmor” (↑*Security Guide*).

## Rules: Owner Conditional Rules

The file rules can be extended so that they can be conditional upon the the user being the owner of the file, by prepending the keyword `owner` to the rule. Owner conditional rules accumulate just as regular file rules and are considered a subset of regular file rules. If a regular file rule overlaps with an owner conditional file rule, the resulting permissions will be that of the regular file rule.

## Rules: Defining Execute Permissions

For executables that may be called from the confined programs, the profile creating tools ask you for an appropriate mode, which is also reflected directly in the profile itself:

| Option        | File | Description   |
|---------------|------|---|
| Inherit       | ix   | Stay in the same (parent's) profile.  |
| Profile       | px   | Requires that a separate profile exists for the executed program. Use <code>Px</code> to make use of environment scrubbing. |
| Local profile | cx   | Requires that a local profile exists for the executed program. Use <code>Cx</code> to make use of environment scrubbing.    |
| Unconstrained | ux   | Executes the program with-  |

| <i>Option</i>            | <i>File</i>    | <i>Description</i>  |
|--------------------------|----------------|---|
|                          |                | out a profile. Avoid running programs in unconstrained or unconfined mode for security reasons. Use <code>Ux</code> to make use of environment scrubbing. |
| Allow Executable Mapping | <code>m</code> | allow <code>PROT_EXEC</code> with <code>mmap(2)</code> calls  |

### WARNING: Running in ux Mode

Avoid running programs in `ux` mode as much as possible. A program running in `ux` mode is not only totally unprotected by AppArmor, but child processes inherit certain environment variables from the parent that might influence the child's execution behavior and create possible security risks.

For more information about the different file execute modes, refer to the `apparmor.d(5)` man page. For more information about `setgid` and `setuid` environment scrubbing, refer to the `ld.so(8)` man page.

## Rules: Paths and Globbing

AppArmor supports explicit handling of directories. Use a trailing `/` for any directory path that needs to be explicitly distinguished:

```
/some/random/example/* r
    Allow read access to files in the /some/random/example directory.
/some/random/example/ r
    Allow read access to the directory only.
/some/**/ r
    Give read access to any directories below /some.
/some/random/example/** r
    Give read access to files and directories under /some/random/example.
/some/random/example/**[^/] r
    Give read access to files under /some/random/example. Explicitly exclude directories ([^/]).
```

To spare users from specifying similar paths all over again, AppArmor supports basic globbing:

| <i>Glob</i>             | <i>Description</i>   |
|-------------------------|--|
| <code>*</code>          | Substitutes for any number of characters, except <code>/</code> .                          |
| <code>**</code>         | Substitutes for any number of characters, including <code>/</code> .                       |
| <code>?</code>          | Substitutes for any single character, except <code>/</code> .                              |
| <code>[ abc ]</code>    | Substitutes for the single character <code>a</code> , <code>b</code> , or <code>c</code> . |
| <code>[ a-c ]</code>    | Substitutes for the single character <code>a</code> , <code>b</code> , or <code>c</code> . |
| <code>{ ab, cd }</code> | Expand to one rule to match <code>ab</code> and another to match <code>cd</code> .         |
| <code>[ ^a ]</code>     | Substitutes for any character except <code>a</code> .                                      |

## Rules: Auditing rules

AppArmor provides the user with the ability to audit given rules so that when they are matched, an audit message will appear in the audit log. To enable audit messages for a given rule the audit keyword is prepended to the rule:

```
audit /etc/foo/* rw,
```

## Rules: Setting Capabilities

Normally, AppArmor only restricts existing native Linux controls and does not grant additional privileges. The only exception from this strict rule is the set capability rule. For security reasons, set capability rules will not be inherited. Once a program leaves the profile, it loses the elevated privilege. Setting a capability also implicitly adds a capability rule allowing that capability. Since this rule gives processes root privileges, it should be used with extreme caution and only in exceptional cases.

```
set capability cap_chown,
```

## Hats

An AppArmor profile represents a security policy for an individual program instance or process. It applies to an executable program, but if a portion of the program needs different access permissions than oth-

er portions, the program can “change hats” to use a different security context, distinctive from the access of the main program. This is known as a hat or sub-profile.

A profile can have an arbitrary number of hats, but there are only two levels: a hat cannot have further hats.

The AppArmor ChangeHat feature can be used by applications to access hats during execution. Currently the packages `apache2-mod_apparmor` and `tomcat_apparmor` utilize ChangeHat to provide sub-process confinement for the Apache Web server and the Tomcat servlet container.

## Confining Users with `pam_apparmor`

The `pam_apparmor` PAM module allows applications to confine authenticated users into subprofiles based on groupnames, usernames, or default profile. To accomplish this, `pam_apparmor` needs to be registered as a PAM session module.

Details about how to set up and configure `pam_apparmor` can be found in `/usr/share/doc/packages/pam_apparmor/README`. A HOWTO on setting up role-based access control (RBAC) with `pam_apparmor` is available at [http://developer.novell.com/wiki/index.php/Apparmor\\_RBAC\\_in\\_version\\_2.3](http://developer.novell.com/wiki/index.php/Apparmor_RBAC_in_version_2.3).

## Logging and Auditing

All AppArmor events are logged using the system's audit interface (the `auditd` logging to `/var/log/audit/audit.log`). On top of this infrastructure, event notification can be configured. Configure this feature using YaST. It is based on severity levels according to `/etc/apparmor/severity.db`. Notification frequency and type of notification (such as e-mail) can be configured.

If `auditd` is not running, AppArmor logs to the system log located under `/var/log/messages` using the `LOG_KERN` facility.

Use YaST for generating reports in CSV or HTML format.

The Linux audit framework contains a dispatcher that can send AppArmor events to any consumer application via `dbus`. The GNOME AppArmor Desktop Monitor applet is one example of an application that gathers AppArmor events via `dbus`. To configure audit to use the `dbus` dispatcher, set the dispatcher in your audit configuration in `/etc/audit/auditd.conf` to `apparmor-dbus` and restart `auditd`:

```
dispatcher=/usr/bin/apparmor-dbus
```

Once the `dbus` dispatcher is configured correctly, add the AppArmor Desktop Monitor to the GNOME panel. As soon as a `REJECT` event is logged, the applet's panel icon changes appearance and you can click the applet to see the number of reject events per confined application. To view the exact log messages, refer to the audit log under `/var/log/audit/audit.log`. Use the YaST Update Profile Wizard to adjust the respective profile.

## Directories and Files

`/sys/kernel/security/apparmor/profiles`  
files

Virtualized file representing the currently loaded set of profiles.

`/etc/apparmor/`

Location of AppArmor configuration files.

`/etc/apparmor/profiles/extras/`

A local repository of profiles shipped with AppArmor, but not enabled by default.

`/etc/apparmor.d/`

Location of profiles, named with the convention of replacing the `/` in pathnames with `.` (not for the root `/`) so profiles are easier to manage. For example, the profile for the program `/usr/sbin/ntpd` is named `usr.sbin.ntpd`.

`/etc/apparmor.d/abstractions/`

Location of abstractions.

`/etc/apparmor.d/program-chunks/`

Location of program chunks.

`/proc/*/attr/current`

Review the confinement status of a process and the profile that is used to confine the process.

The `ps auxZ` command retrieves this information automatically.

## For More Information

To learn more about the AppArmor project, check out the project's home page under <http://en.opensuse.org/AppArmor>. Find more information on the concept and the configuration of AppArmor in Part “Confining Privileges with AppArmor” (↑*Security Guide*).

## Legal Notice

Copyright© 2006–2015 SUSE LLC and contributors. All rights reserved.

Permission is granted to copy, distribute and/or modify this document under the terms of the GNU Free Documentation License, Version 1.2 or (at your option) version 1.3; with the Invariant Section being this copyright notice and license. A copy of the license version 1.2 is included in the section entitled “GNU Free Documentation License”.

For SUSE and Novell trademarks, see the Novell Trademark and Service Mark list <http://www.novell.com/company/legal/trade->

`marks/tmlist.html`. All other third party trademarks are the property of their respective owners. A trademark symbol (®, ™ etc.) denotes a SUSE or Novell trademark; an asterisk (\*) denotes a third party trademark.

All information found in this book has been compiled with utmost attention to detail. However, this does not guarantee complete accuracy. Neither SUSE LLC, its affiliates, the authors, nor the translators shall be held liable for possible errors or the consequences thereof.



# GNU Free Documentation License

Copyright (C) 2000, 2001, 2002 Free Software Foundation, Inc. 51 Franklin St, Fifth Floor, Boston, MA 02110-1301 USA. Everyone is permitted to copy and distribute verbatim copies of this license document, but changing it is not allowed.

## 0. PREAMBLE

The purpose of this License is to make a manual, textbook, or other functional and useful document "free" in the sense of freedom: to assure everyone the effective freedom to copy and redistribute it, with or without modifying it, either commercially or noncommercially. Secondly, this License preserves for the author and publisher a way to get credit for their work, while not being considered responsible for modifications made by others.

This License is a kind of "copyleft", which means that derivative works of the document must themselves be free in the same sense. It complements the GNU General Public License, which is a copyleft license designed for free software.

We have designed this License in order to use it for manuals for free software, because free software needs free documentation: a free program should come with manuals providing the same freedoms that the software does. But this License is not limited to software manuals; it can be used for any textual work, regardless of subject matter or whether it is published as a printed book. We recommend this License principally for works whose purpose is instruction or reference.

## 1. APPLICABILITY AND DEFINITIONS

This License applies to any manual or other work, in any medium, that contains a notice placed by the copyright holder saying it can be distributed under the terms of this License. Such a notice grants a world-wide, royalty-free license, unlimited in duration, to use that work under the conditions stated herein. The "Document", below, refers to any such manual or work. Any member of the public is a licensee, and is addressed as "you". You accept the license if you copy, modify or distribute the work in a way requiring permission under copyright law.

A "Modified Version" of the Document means any work containing the Document or a portion of it, either copied verbatim, or with modifications and/or translated into another language.

A "Secondary Section" is a named appendix or a front-matter section of the Document that deals exclusively with the relationship of the publishers or authors of the Document to the Document's overall subject (or to related matters) and contains nothing that could fall directly within that overall subject. (Thus, if the Document is in part a textbook of mathematics, a Secondary Section may not explain any mathematics.) The relationship could be a matter of historical connection with the subject or with related matters, or of legal, commercial, philosophical, ethical or political position regarding them.

The "Invariant Sections" are certain Secondary Sections whose titles are designated, as being those of Invariant Sections, in the notice that says that the Document is released under this License. If a section does not fit the above definition of Secondary then it is not allowed to be designated as Invariant. The Document may contain zero Invariant Sections. If the Document does not identify any Invariant Sections then there are none.

The "Cover Texts" are certain short passages of text that are listed, as Front-Cover Texts or Back-Cover Texts, in the notice that says that the Document is released under this License. A Front-Cover Text may be at most 5 words, and a Back-Cover Text may be at most 25 words.

A "Transparent" copy of the Document means a machine-readable copy, represented in a format whose specification is available to the general public, that is suitable for revising the document straightforwardly with generic text editors or (for images composed of pixels) generic paint programs or (for drawings) some widely available drawing editor, and that is suitable for input to text formatters or for automatic translation to a variety of formats suitable for input to text formatters. A copy made in an otherwise Transparent file format whose markup, or absence of markup, has been arranged to thwart or discourage subsequent modification by readers is not Transparent. An image format is not Transparent if used for any substantial amount of text. A copy that is not "Transparent" is called "Opaque".

Examples of suitable formats for Transparent copies include plain ASCII without markup, Texinfo input format, LaTeX input format, SGML or XML using a publicly available DTD, and standard-conforming simple HTML, PostScript or PDF designed for human modification. Examples of transparent image formats include PNG, XCF and JPG. Opaque formats include proprietary formats that can be read and edited only by proprietary word processors, SGML or XML for which the DTD and/or processing tools are not generally available, and the machine-generated HTML, PostScript or PDF produced by some word processors for output purposes only.

The "Title Page" means, for a printed book, the title page itself, plus such following pages as are needed to hold, legibly, the material this License requires to appear in the title page. For works in formats which do not have any title page as such, "Title Page" means the text near the most prominent appearance of the work's title, preceding the beginning of the body of the text.

A section "Entitled XYZ" means a named subunit of the Document whose title either is precisely XYZ or contains XYZ in parentheses following text that translates XYZ in another language. (Here XYZ stands for a specific section name mentioned below, such as "Acknowledgements", "Dedications", "Endorsements", or "History".) To "Preserve the Title" of such a section when you modify the Document means that it remains a section "Entitled XYZ" according to this definition.

The Document may include Warranty Disclaimers next to the notice which states that this License applies to the Document. These Warranty Disclaimers are considered to be included by reference in this License, but only as regards disclaiming warranties: any other implication that these Warranty Disclaimers may have is void and has no effect on the meaning of this License.

## 2. VERBATIM COPYING

You may copy and distribute the Document in any medium, either commercially or noncommercially, provided that this License, the copyright notices, and the license notice saying this License applies to the Document are reproduced in all copies, and that you add no other conditions whatsoever to those of this License. You may not use technical measures to obstruct or control the reading or further copying of the copies you make or distribute. However, you may accept compensation in exchange for copies. If you distribute a large enough number of copies you must also follow the conditions in section 3.

You may also lend copies, under the same conditions stated above, and you may publicly display copies.

## 3. COPYING IN QUANTITY

If you publish printed copies (or copies in media that commonly have printed covers) of the Document, numbering more than 100, and the Document's license notice requires Cover Texts, you must enclose the copies in covers that carry, clearly and legibly, all these Cover Texts: Front-Cover Texts on the front cover, and Back-Cover Texts on the back cover. Both covers must also clearly and legibly identify you as the publisher of these copies. The front cover must present the full title with all words of the title equally prominent and visible. You may add other material on the covers in addition. Copying with changes limited to the covers, as long as they preserve the title of the Document and satisfy these conditions, can be treated as verbatim copying in other respects.

If the required texts for either cover are too voluminous to fit legibly, you should put the first ones listed (as many as fit reasonably) on the actual cover, and continue the rest onto adjacent pages.

If you publish or distribute Opaque copies of the Document numbering more than 100, you must either include a machine-readable Transparent copy along with each Opaque copy, or state in or with each Opaque copy a computer-network location from which the general network-using public has access to download using public-standard network protocols a complete Transparent copy of the Document, free of added material. If you use the latter option, you must take reasonably prudent steps, when you begin distribution of Opaque copies in quantity, to ensure that this Transparent copy will remain thus accessible at the stated location until at least one year after the last time you distribute an Opaque copy (directly or through your agents or retailers) of that edition to the public.

It is requested, but not required, that you contact the authors of the Document well before redistributing any large number of copies, to give them a chance to provide you with an updated version of the Document.

## 4. MODIFICATIONS

You may copy and distribute a Modified Version of the Document under the conditions of sections 2 and 3 above, provided that you release the Modified Version under precisely this License, with the Modified Version filling the role of the Document, thus licensing distribution and modification of the Modified Version to whoever possesses a copy of it. In addition, you must do these things in the Modified Version:

- A. Use in the Title Page (and on the covers, if any) a title distinct from that of the Document, and from those of previous versions (which should, if there were any, be listed in the History section of the Document). You may use the same title as a previous version if the original publisher of that version gives permission.
- B. List on the Title Page, as authors, one or more persons or entities responsible for authorship of the modifications in the Modified Version, together with at least five of the principal authors of the Document (all of its principal authors, if it has fewer than five), unless they release you from this requirement.
- C. State on the Title page the name of the publisher of the Modified Version, as the publisher.
- D. Preserve all the copyright notices of the Document.
- E. Add an appropriate copyright notice for your modifications adjacent to the other copyright notices.
- F. Include, immediately after the copyright notices, a license notice giving the public permission to use the Modified Version under the terms of this License, in the form shown in the Addendum below.
- G. Preserve in that license notice the full lists of Invariant Sections and required Cover Texts given in the Document's license notice.
- H. Include an unaltered copy of this License.
- I. Preserve the section Entitled "History", Preserve its Title, and add to it an item stating at least the title, year, new authors, and publisher of the Modified Version as given on the Title Page. If there is no section Entitled "History" in the Document, create one stating the title, year, authors, and publisher of the Document as given on its Title Page, then add an item describing the Modified Version as stated in the previous sentence.
- J. Preserve the network location, if any, given in the Document for public access to a Transparent copy of the Document, and likewise the network locations given in the Document for previous versions it was based on. These may be placed in the "History" section. You may omit a network location for a work that was published at least four years before the Document itself, or if the original publisher of the version it refers to gives permission.
- K. For any section Entitled "Acknowledgements" or "Dedications", Preserve the Title of the section, and preserve in the section all the substance and tone of each of the contributor acknowledgements and/or dedications given therein.
- L. Preserve all the Invariant Sections of the Document, unaltered in their text and in their titles. Section numbers or the equivalent are not considered part of the section titles.
- M. Delete any section Entitled "Endorsements". Such a section may not be included in the Modified Version.
- N. Do not retitle any existing section to be Entitled "Endorsements" or to conflict in title with any Invariant Section.
- O. Preserve any Warranty Disclaimers.

If the Modified Version includes new front-matter sections or appendices that qualify as Secondary Sections and contain no material copied from the Document, you may at your option designate some or all of these sections as invariant. To do this, add their titles to the list of Invariant Sections in the Modified Version's license notice. These titles must be distinct from any other section titles.

You may add a section Entitled "Endorsements", provided it contains nothing but endorsements of your Modified Version by various parties—for example, statements of peer review or that the text has been approved by an organization as the authoritative definition of a standard.

You may add a passage of up to five words as a Front-Cover Text, and a passage of up to 25 words as a Back-Cover Text, to the end of the list of Cover Texts in the Modified Version. Only one passage of Front-Cover Text and one of Back-Cover Text may be added by (or through arrangements made by) any one entity. If the Document already includes a cover text for the same cover, previously added by you or by arrangement made by the same entity you are acting on behalf of, you may not add another; but you may replace the old one, on explicit permission from the previous publisher that added the old one.

The author(s) and publisher(s) of the Document do not by this License give permission to use their names for publicity for or to assert or imply endorsement of any Modified Version.

## 5. COMBINING DOCUMENTS

You may combine the Document with other documents released under this License, under the terms defined in section 4 above for modified versions, provided that you include in the combination all of the Invariant Sections of all of the original documents, unmodified, and list them all as Invariant Sections of your combined work in its license notice, and that you preserve all their Warranty Disclaimers.

The combined work need only contain one copy of this License, and multiple identical Invariant Sections may be replaced with a single copy. If there are multiple Invariant Sections with the same name but different contents, make the title of each such section unique by adding at the end of it, in parentheses, the name of the original author or publisher of that section if known, or else a unique number. Make the same adjustment to the section titles in the list of Invariant Sections in the license notice of the combined work.

In the combination, you must combine any sections Entitled "History" in the various original documents, forming one section Entitled "History"; likewise combine any sections Entitled "Acknowledgements", and any sections Entitled "Dedications". You must delete all sections Entitled "Endorsements".

## 6. COLLECTIONS OF DOCUMENTS

You may make a collection consisting of the Document and other documents released under this License, and replace the individual copies of this License in the various documents with a single copy that is included in the collection, provided that you follow the rules of this License for verbatim copying of each of the documents in all other respects.

You may extract a single document from such a collection, and distribute it individually under this License, provided you insert a copy of this License into the extracted document, and follow this License in all other respects regarding verbatim copying of that document.

## 7. AGGREGATION WITH INDEPENDENT WORKS

A compilation of the Document or its derivatives with other separate and independent documents or works, in or on a volume of a storage or distribution medium, is called an "aggregate" if the copyright resulting from the compilation is not used to limit the legal rights of the compilation's users beyond what the individual works permit. When the Document is included in an aggregate, this License does not apply to the other works in the aggregate which are not themselves derivative works of the Document.

If the Cover Text requirement of section 3 is applicable to these copies of the Document, then if the Document is less than one half of the entire aggregate, the Document's Cover Texts may be placed on covers that bracket the Document within the aggregate, or the electronic equivalent of covers if the Document is in electronic form. Otherwise they must appear on printed covers that bracket the whole aggregate.

## 8. TRANSLATION

Translation is considered a kind of modification, so you may distribute translations of the Document under the terms of section 4. Replacing Invariant Sections with translations requires special permission from their copyright holders, but you may include translations of some or all Invariant Sections in addition to the original versions of these Invariant Sections. You may include a translation of this License, and all the license notices in the Document, and any Warranty Disclaimers, provided that you also include the original English version of this License and the original versions of those notices and disclaimers. In case of a dis-

agreement between the translation and the original version of this License or a notice or disclaimer, the original version will prevail.

If a section in the Document is Entitled "Acknowledgements", "Dedications", or "History", the requirement (section 4) to Preserve its Title (section 1) will typically require changing the actual title.

## 9. TERMINATION

You may not copy, modify, sublicense, or distribute the Document except as expressly provided for under this License. Any other attempt to copy, modify, sublicense or distribute the Document is void, and will automatically terminate your rights under this License. However, parties who have received copies, or rights, from you under this License will not have their licenses terminated so long as such parties remain in full compliance.

## 10. FUTURE REVISIONS OF THIS LICENSE

The Free Software Foundation may publish new, revised versions of the GNU Free Documentation License from time to time. Such new versions will be similar in spirit to the present version, but may differ in detail to address new problems or concerns. See <http://www.gnu.org/copyleft/>.

Each version of the License is given a distinguishing version number. If the Document specifies that a particular numbered version of this License "or any later version" applies to it, you have the option of following the terms and conditions either of that specified version or of any later version that has been published (not as a draft) by the Free Software Foundation. If the Document does not specify a version number of this License, you may choose any version ever published (not as a draft) by the Free Software Foundation.

## ADDENDUM: How to use this License for your documents

Copyright (c) YEAR YOUR NAME.  
Permission is granted to copy, distribute and/or modify this document under the terms of the GNU Free Documentation License, Version 1.2 or any later version published by the Free Software Foundation; with no Invariant Sections, no Front-Cover Texts, and no Back-Cover Texts. A copy of the license is included in the section entitled "GNU Free Documentation License".

If you have Invariant Sections, Front-Cover Texts and Back-Cover Texts, replace the "with...Texts." line with this:

with the Invariant Sections being LIST THEIR TITLES, with the Front-Cover Texts being LIST, and with the Back-Cover Texts being LIST.

If you have Invariant Sections without Cover Texts, or some other combination of the three, merge those two alternatives to suit the situation.

If your document contains nontrivial examples of program code, we recommend releasing these examples in parallel under your choice of free software license, such as the GNU General Public License, to permit their use in free software.

